A COMPRESSION-DECOMPRESSION SCHEDULE FOR PRODUCING DYSBARIC STRESS IN MATURE RATS

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SUMMARY PAGE

THE PROBLEM

To develop a compression-decompression profile for producing severe dysbaric stress in mature male rats.

FINDINGS

A table was developed for a dive which would allow a 66% survival rate one hour post-surfacing and could be accomplished in 72 minutes of chamber time.

APPLICATION

The schedule produces severe dysbaric stress in mature male rats creating a family of lesions that can be studied by biochemical and physiological analyses.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit M4306.02-5003BA9K. The present report is Number 2 on this work unit. It was submitted for review on 12 June 1973, approved for publication on 8 August 1973 and designated as NavSubMedRschLab Report No. 749.

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ABSTRACT

A need arose to develop a compression-decompression table that would insure a proper degree of severe decompression stress in rats. Severe decompression stress has been defined as that stress which is neither safe, allowing complete (100%) survival, nor excessively hazardous (explosive) resulting in a 90-100% death rate within one hour post-surfacing. By these criteria, then, a 66% survival rate documents severe decompression. This report details a schedule with 72 minutes of chamber time which will routinely produce severe decompression stress in rats. This schedule was employed as a model for a study of the effects of decompression accidents which may be encountered by human divers.

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INTRODUCTION

A review of the pertinent literature on compression-decompression schedules capable of inducing decompression sickness in small laboratory animals indicated that previously published dive profiles were not appropriate for application to the problems under investigation in our laboratory. An explosive decompression approach was ruled out because of its lack of practical applicability. Compression-decompression schedules which feature altitude decompression, with or without exercise or the use of lipid-loaded[8] or genetically susceptible animals[2] were considered less than physiologically significant for studying questions related to the needs of Navy divers.

METHODS

Mature Sprague-Dawley male rats weighing about 500 grams were chosen as subject material for this study. Our choice of these animals was based on the following considerations:

a. Adequate tissue samples: Blood sample sizes ranging from 10-13 ml are routinely obtained from the abdominal aorta of large rats.

b. Economy: Obtained as former breeding stock.

c. Ideal Age: Age and/or obesity are contributing factors to the incidence of decompression sickness.[1]

The outer lock of the Naval Submarine Medical Research Laboratory's man-rated pressure chamber, volume approximately 475 cu.ft., was utilized as our standard excursion vehicle.

Experimental Design Considerations:

During the evolution of the compression-decompression profile, our attention was drawn to a report by the Canadian group at Downsview[9]. Their experimental protocol featured human excursions to 300 feet of sea water (FSW) for 30 minutes with stage decompression. The first stop was 60 FSW with an ascent speed between 300 and 60 FSW of 20 feet/minute.

As a preliminary experiment, a group of animals were compressed to 300 FSW, decompressed to 60 FSW and held at this depth for several hours. All experimental animals tolerated this procedure remarkably well. No signs of decompression sickness were noted. In a subsequent series of experiments, a double excursion was carried out i.e., surface to 300 FSW to 60 FSW to 300 FSW to 60 FSW. The animals were again held at 60 FSW without any visible symptoms of decompression sickness. As long as the 60 foot level was not exceeded, no apparent decompression problems occurred.

Early attempts to bring the animals from 60 feet to the surface even after a 30-min. hold resulted in death of most animals. Information for the solution of this problem was found in the

report from the Royal Navy Physiological Laboratory by Trotter[11] in which decompression schedules were calculated by assuming that ascent rate should be inversely proportional to the square root of time-of-ascent. By extrapolation from the safe decompression schedules calculated from small animals[11] and from our experience with more rapid decompression rates, it was estimated that a total decompression time of 40-45 minutes should result in a schedule that would allow most of the animals to survive but which would result in a considerable degree of decompression insult. Therefore, with the employment of the initial 20 ft/min ascent rates between 300 FSW and 60 FSW plus a 15 minute stop at 60 FSW and an ascent rate of 4 ft/min to the surface, a convenient schedule was derived which provided a 42 minute decompression time.

RESULTS

Table 1 and Figure 1 show, respectively, the minute-by-minute dive profile details and comparison between the schedule utilized here and a decompression which is strictly proportional to the square root of decompression time. Table 2 summarizes the results of eight dives involving 486 rats. It can be seen that the above dive profile employed for the large adult Sprague-Dawley rat produces a 66% survival rate after one hour post-surfacing. Temperature profiles for the minimum, 73° F and maximum, 83°F, ambient temperature conditions encountered during the series of eight dives are depicted in Figure 2.

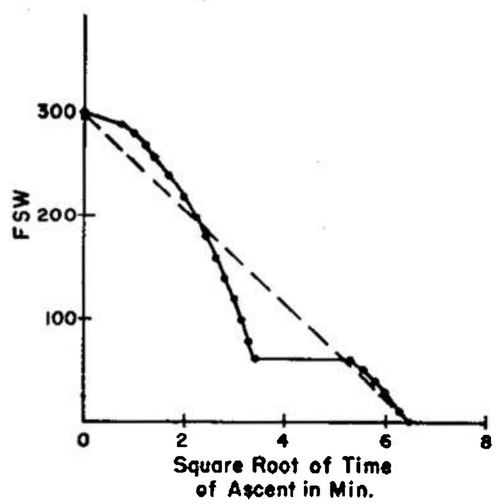

Fig. 1. A comparison between a decompression which is strictly proportional to the square root of decompression time and the schedule outlined in Table 1.

Table 1. Minute by Minute Scenario For Production of Severe Dysbaric Stress in Mature Sprague-Dawley Rats

TIME INTERVAL	DEPTH	TIME INTERVAL	DEPTH
(Min)	(FSW)	(Min)	(FSW)
0	Surface	37	160
1	60	38	140
2	120	39	120
3	180	40	100
4	240	41	80
5 Bottom: Start Vent	300	42 Start Hold	60
6	300	43	60
7	300	44	60
8	300	45	60
9	300	46	60
10 Vent Complete	300	47	60
11	300	48	60
12	300	49	60
13	300	50	60
14	300	51	60
15	300	52	60
16	300	53	60
17	300	54	60
18	300	55	60
19	300	56	60
20	300	57 Leave 60'	60
21	300	58	56
22	300	59	52
23	300	60	48
24	300	61	44
25	300	62	40
26	300	63	36
27	300	64	32
28	300	65	28
29	300	66	24
30 Start Decompression	300	67	20
31	280	68	16
32	260	69	12
33	240	70	8
34	220	71	4
35	200	72	Surface
36	180		

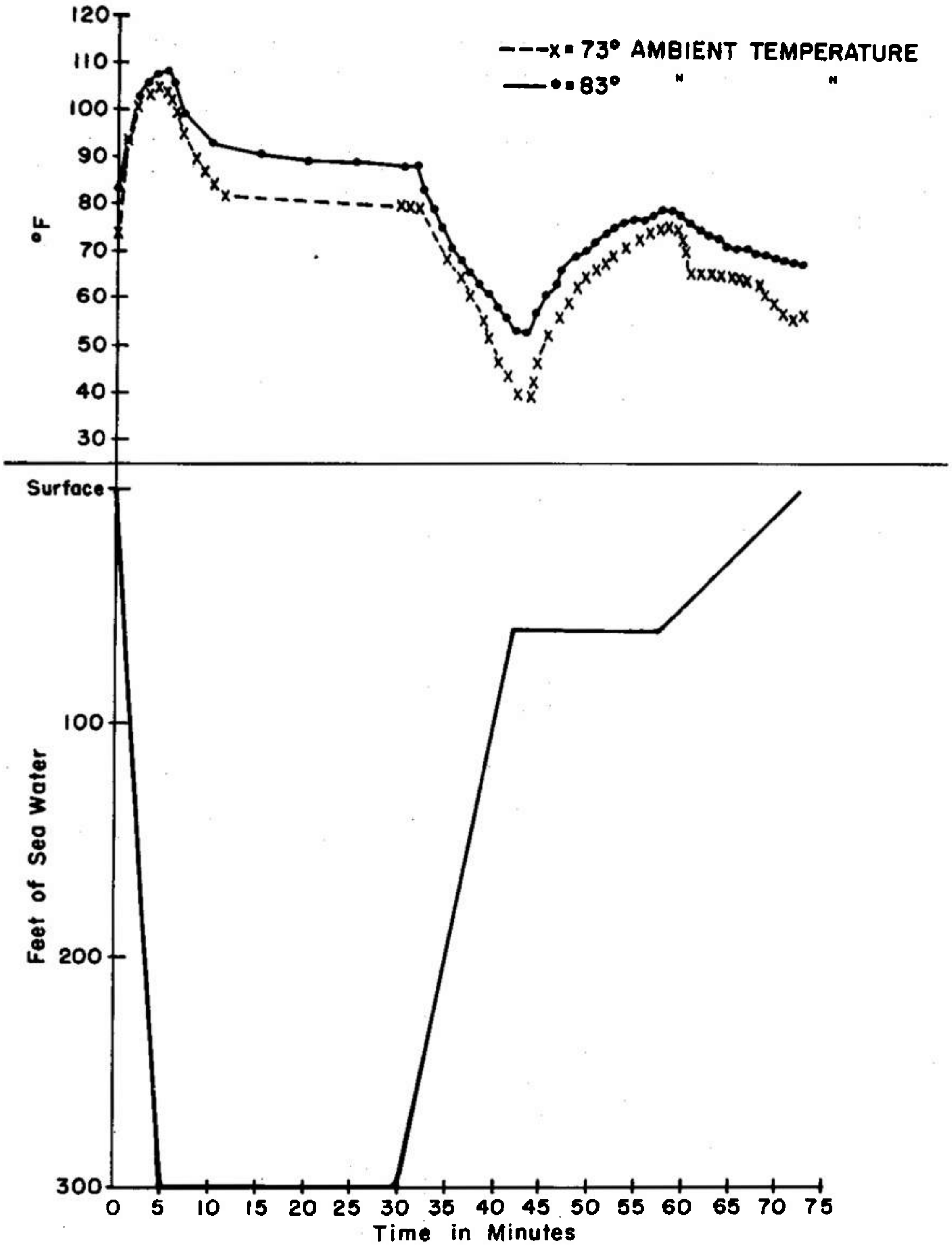

Fig. 2. Temperature profiles for the minimum and maximum ambient temperature conditions encountered during the series of eight dives. These are shown superimposed upon a linear representation of the dive profile.

Table 2. Survival Data on Mature Sprague-Dawley Rats Following Pressurization and Decompression According to The Scenario Outlined in Table 1

DIVE NO.	NO. OF ANIMALS PRESSURIZED	NO. OF ANIMALS SURVIVING AFTER 1 HR. POST-DECOMPRESSION	% SURVIVAL
1	65	49	75
2	70	29	42
3	55	34	62
4	50	32	64
5	63	40	63
6	64	51	80
7	59	38	65
8	60	45	75
TOTAL	486	318	66%

DISCUSSION

The endocrine system, an important regulator of the number of leucocytes in the blood, affects the production of leucocytes in the blood-forming organs, their storage and release from tissues and their disintegration[6]. The studies of Selye[8] on the alarm reaction demonstrated that as a result of stress, animals show a typical hematological triad of lymphopenia, eosinopenia and neutrophilia. Later, Gordon[3] showed that the same effects were produced by the administration of ACTH and that the lymphopenic response to ACTH is abolished by adrenalectomy. Selye[10] also reported that within a few hours after the alarm reaction, there is a marked disintegration of lymphocytes which is preventable by adrenelectomy. In contrast, stress and adrenal pituitary factors produce an enhancement of the number of circulating neutrophils. Neutrophilic leucocytosis is probably produced by myelopoiesis in the bone

marrow and is further augmented by increased release of neutrophils from the bone marrow, lungs, and other organs.[6]

Pressurization and decompression of mature male Sprague-Dawley rats with the schedule described herein caused an acute transient lymphocytic leucopenia together with a relative and absolute neutrophilia within one hour post-surfacing.[5] All white cell count parameters returned to control values at one day post-decompression. The acute leucocytic changes following severe decompression fit the well-established concept of adrenal cortical response to stress.

Fluid loss caused by diaphoresis due to excessive chamber temperature have been suggested by Philp and co-workers[7] as a partial explanation of the hemoconcentration noted by them in diving experiments. In our experiments, a peak in chamber temperatures resulting from compression of gas was produced at the end of compression to 300 FSW, at 5 minutes from the surface, and was promptly corrected by venting and subsequent decompression. The temperature profiles provide evidence that the heat stress encountered by the animals was minimal.

An ancillary observation arising from these efforts has been that assuming a double lock man-rated chamber is available, laboratory animals may be studied at any depth within the 300 FSW to 60 FSW envelope following a variety of compression or decompression schedules without decompression problems. Human tenders may then be locked into one portion of the chamber, pressurized to the proper depth, and blood or tissue samples obtained. Since there are typically no symptoms of decompression sickness, it is possible to study the effects of compression schedules or pressure in the absence of most decompression effects. The diving schedule that has been developed is simple in design, requires a minimum number of manipulations by chamber operators and is capable of producing biochemical, hematological and hemostatic alterations in mature male rats. The method has already proven useful for investigating several aspects of decompression injury.[4,5]

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13. ABSTRACT

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Dysbarism						